SEASONING WOOD FOR SHIP CONSTRUCTION

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The resurgence of wood as a prime shipbuilding material during the past two years has brought this industry face to face with a difficult production bottleneck: a shortage of properly seasoned stock. This situation threatens to become more acute as time goes on because ship builders generally prefer air-seasoned material; and air seasoning is by nature slow and uncertain, requiring months and even years for the larger sizes of ship timbers. It can, however, be speeded to some extent by proper handling and piling of green lumber.

A quicker alternative is kiln drying. Modern kilns can produce lumber for shipbuilders in weeks instead of the months or years required for air seasoning. It is true that the industry has in the past exhibited a general preference for air-dried stock. This preference, however, was undoubtedly due in large part to the fact that the kiln-dried stock used was not properly dried for shipbuilding. It does not follow, however, that modern kilns cannot produce lumber suitable for ship construction; the problem lies in the proper drying of the stock for ships, rather than in the relative merits of air and kiln drying.

It is recognized, nevertheless, that existing kiln capacity may not be available for much of the lumber needed for ship construction; faster air seasoning then becomes a necessity. This article reviews methods by which air seasoning can be hastened, together with other phases of the material problem confronting shipbuilders today.

Seasoning Requirements

The seasoning problems of a builder of wood ships differ in many respects from those of most other wood craftsmen. In all but the smaller types of boats, use conditions are such that some parts of the boat, such as keels and bottom planking, are under water, and material used for these parts needs no seasoning to fit it for the exposure conditions that occur in service. Material used for planking above the water line, decking, and interior construction should be seasoned to the moisture content that it will attain in use. Except for cabinet work and joinery, all wood used in ships will have an optimum moisture content definitely higher than that for most other commercial uses.

Use conditions, however, are not the only factors that control the requirements for seasoning of the various parts, particularly those used under water. During construction either in the open or under cover, the framework and planking are exposed to the atmosphere, and any green or unseasoned material will be subject to conditions that cause rapid surface drying, generally accompanied by serious checking and some shrinkage. To prevent or minimize defects that might develop during the construction period, therefore, some preseasoning is desirable even for parts that in service are always under water.

If such under-water material is adequately seasoned before use it will not check, split, warp, or shrink during construction, and the slight swelling that occurs after launching will help make the seams tight. The optimum moisture content is from 15 to 20 percent. As an alternate, because of the shortage of seasoned material, some shipbuilders of necessity use green material and attempt to prevent drying during construction by applying moisture-repellent coatings to the parts after they have been shaped. The methods generally used are only partially effective, and often the parts are subject to considerable checking and some shrinkage. Soaking treatments with hygroscopic chemicals, on the other hand, offer an effective means of retaining moisture in green wood during construction, and are discussed here for that purpose. All unseasoned stock received by the boatbuilder should, of course, be properly piled in the yard or shed so as to protect it against damage from checking and splitting and, at the same time, to obtain as much seasoning as possible before it is processed.

Moisture in Wood

Wood green from the tree may contain from 30 to 300 percent water, based on the dry weight of the wood. This water is held in the wood in two distinct ways; about 25 to 30 percent is imbibed in the cell walls, and the balance, free water, is in the cell cavities. Shrinkage starts with the evaporation of the imbibed water from the cell walls, which takes place after the free water is gone. Since, in seasoning green wood, the surface dries more rapidly than the interior and reaches the fiber-saturation point first, shrinkage starts in that part even though little or no drying has taken place in the interior.

This unequal drying is the principal cause of surface and end checking. The greater the difference in moisture content between the surface and the interior below the fiber-saturation point, the greater the stresses developed. Through control of drying conditions, it is possible to minimize the moisture gradient and, thereby, checking and splitting.

When wood is subjected to a constant temperature and relative humidity, it will in time come to a definite moisture content called the equilibrium moisture content, which is determined by the prevailing humidity. This relationship between the moisture content of wood and the surrounding atmospheric conditions is shown on figure 1.

Air Drying of Lumber

Through control of the relative humidity, it is possible to control the moisture content of wood. The rate of transfusion of moisture through wood is faster at high than at low temperatures. In air drying in yards or open sheds, it is not possible to control the temperature, but through proper piling methods it is possible to obtain some degree of control of the humidity within a pile of lumber and, thus, to increase or decrease the rate of drying as desired. Some species, such as oak, are liable to surface and end check, and must be dried slowly to minimize checking. Most softwoods can be dried more rapidly with safety. As the thickness increases, the tendency to check becomes more pronounced in all species. In air drying, the methods of control are limited to methods of piling or covering of the pile that increase or decrease the volume of air moving through the pile.

The term "air dry," as used by lumbermen, applies to material that has been exposed to the air for any length of time. If exposed for a sufficient time, it may have a moisture content ranging from 6 percent, as in summer in the arid Southwest, to 24 percent, as in winter in the Pacific Northwest. For the United States as a whole, the minimum moisture content range for thoroughly air-dry 1-inch lumber is 12 to 15 percent in the summer, and the average is somewhat higher.

Piling for air seasoning should accomplish a number of objectives: It should provide for proper air circulation, it should offer suitable protection from sun and rain, and it should keep boards straight and flat while they are drying. If these things are accomplished, the best drying will result and drying defects will be at a minimum. Among such defects are stain and decay, end and surface checking, and warping. No one rule will apply to all weather conditions and to all classes of stock; some species, particularly in grades containing sapwood must be open piled to hasten drying and thereby avert stain; while others, such as the oaks, must be close piled to prevent too rapid drying, which may cause checking.

The following general principles will apply to most seasoning yards:

Stain Prevention.--If it is known that stain is likely to occur, freshly cut lumber containing sapwood should be dipped in or sprayed with an antistain solution for protection against the attacks of staining fungi during the air-seasoning period.

Logs of some species are often badly infected with stain before they are sawed into lumber. Where immediate sawing of unstained logs is impossible, and when insect infestations are not severe, a practical method of controlling stain is provided by chemical treatment. The treatment can be made with an ordinary garden spray, but should not be delayed longer than 24 hours after the trees are felled.

In the absence of severe insect infestations, spraying the ends and barked areas of freshly cut hardwood logs with some stain retardant will substantially retard the occurrence of blue stain during storage periods of as

much as 3 months. The same treatments are suitable for softwood logs, but may not give adequate protection for so long a period. Information as to where such chemical treatments can be obtained can be found in any current lumber trade journal.

All chemicals and chemical mixtures used for this purpose are more or less poisonous. Care must be taken to follow the directions of the manufacturers closely and to protect the skin and eyes. Vessels used in mixing and applying chemicals should be thoroughly cleaned, and left-over chemicals either destroyed in a safe manner or plainly marked and stored where they will not be readily accessible to children or animals.

Simply-constructed dipping tanks can be used for treating freshly-cut lumber. For maximum effectiveness and safety in handling, manufacturers' directions should be followed. For hand dipping and handling of treated lumber, waterproof aprons and rubber gloves protected by canvas or leather pads to reduce wear, are advised.

Foundations.--The pile foundations (pile bottoms) should be constructed as follows:

(a) The foundations should be rigid and properly leveled.

(b) The foundations should be high enough from the ground to allow good circulation. The distance from the ground to the under side of the lumber at the rear of the pile should be not less than 18 inches.

(c) Foundations should slope from front to rear about 1 inch to the foot.

(d) Material for piers: may be of concrete, masonry, pressure-creosoted blocks of any species, or the heartwood of baldcypress, redwood, or cedar. (When untreated woods are used, all points of contact should be given two coats of hot creosote.)

(e) Beams and stringers should preferably be pressure-creosoted timbers, or steel if available. Untreated heartwood of durable woods, painted with two coats of hot creosote at points of contact, may be used when the first two are not available.

(f) If existing pile bottoms are to be used, they should be inspected to see that they comply with required height levels and drainage conditions. All vegetation, debris, and decayed wood should be cleared away. Any part of the pile bottom containing decay should be removed or the decayed area cut out. All wood parts should be painted with two coats of hot creosote.

Air Flues.--The following suggestions are offered as minimum requirements:

(a) Stock 10 inches and wider should have spaces between the boards or planks not less than 20 percent of the width of the board. The boards in each succeeding layer should be placed directly over the boards below so that the spaces between boards will form uninterrupted vertical flues. Two or more narrow boards can be placed edge to edge between flues. The distance between flues should not exceed 16 inches.

(b) Heavy plank and timbers should be piled so that flues at least one but not over two inches wide are formed between adjacent pieces, otherwise being piled as described for boards.

Stickers.--The following suggestions are offered as minimum requirements:

(a) All stickers must be sound, thoroughly dry, free from stain, and of even thickness.

(b) Each tier of stickers should be aligned and rest over a beam.

(c) Stickers for 4/4-inch lumber should be of nominal inch stock or thicker and not more than 4 inches wide. For thicker lumber of random length, stickers should be at least 1-1/2 inches thick and not over 4 inches wide.

(d) Stickers should extend slightly beyond the ends of the stock to reduce end checking.

(e) Stickers should not be over 2 feet apart for hardwoods up to 6/4 inch in thickness. For thicker hardwoodsand all softwoods, the equivalent of five tiers of stickers for 16-foot stock should be used.

(f) Stock should never be self-stickered.

Placing of Lumber.--The following suggestions are offered as minimum requirements:

(a) Piles should be erected of boards of equal length wherever practicable.

(b) Box piling should be used for mixed lengths. With this system the longest stock is piled in the outer tiers and short lengths within the pile, with one end of a board at one end of the pile and one end of the adjacent board at the opposite end of the pile. In each succeeding layer, the outside ends of boards should be kept immediately over the ends of those below.

(c) Each layer should be composed of boards of the same thickness.

(d) The pile should have a forward slope or pitch to the extent of 1 inch for each foot of height.

(e) Narrow piles are desirable for stock that will withstand rapid drying or that is subject to stain, such as material containing sapwood. Wide piles or narrow spaces between piles are desirable for stock such as oak, drying of which must be retarded to prevent checking.

(f) Space between piles should be 2 feet for oak and 4 to 6 feet for softwoods generally.

End Coatings.--End coatings offer an effective means of protection against end checking and splitting and should be applied to freshly cut ends. After end checks develop, coatings are of little value, but the checked ends can be trimmed off and the fresh ends coated to prevent the checks from extending deeper into the piece during subsequent seasoning.

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The coatings ordinarily used are of two classes. The first are liquid at ordinary temperatures and can be applied cold. The second are solid at ordinary temperatures and must be applied hot. Cold coatings have the advantage that they may be used easily on logs and lumber; hot coatings, because of the method of application (end dipping), are not easy to use on large stock.

Melted paraffine has proved very satisfactory as an end coating for stock during air seasoning. A cold coating developed at the Forest Products Laboratory is hardened gloss oil thickened with barytes and magnesium silicate.

The manufacture of hardened gloss oil involves technical operations and should not be attempted by the novice. Because gloss oil is made commercially in a number of ways and because some of the products are unsuited for end coatings, a gloss oil should be specified which is made in accordance with the following formula:

8	parts	by	weight	quick lime
100	"	"	"	rosin
57.5	"	"	"	spirit

To 100 parts of this gloss oil add 25 parts barytes and 25 parts magnesium silicate of a grade commonly used as a pigment for paints. One or two parts of lampblack may also be added if a black coating is desired. The magnesium silicate helps to keep the pigment in suspension. In time, however, it will settle, and the spirit will evaporate. As a result of these two actions the filled, hardened gloss oil tends to become pasty if allowed to stand any considerable period. It is suggested, therefore, that the user protect his gloss oil from evaporation and mix relatively small quantities of it with the barytes and magnesium silicate as needed.

Covering.--All material should be under cover, either in an open shed or with covers for individual piles. One satisfactory type of pile roof consists of two layers of low-grade boards, those in the upper layer being staggered with respect to those in the lower layer.

(a) A minimum front height of 6 inches above the lumber, with a slope of at least 1 inch to the foot, should be required.

(b) The ends and sides of the cover should project sufficiently to prevent snow and rain from beating into the pile.

(c) The roof should be securely fastened.

Site.--The yard should be well drained and kept free of weeds and debris.

Kiln Drying of Lumber

The kiln drying of green lumber to a moisture content suited to boat construction should produce material fully equal, if not superior to, air-dried stock, and in very much less time. Since boat stock should have a moisture content materially higher than stock kiln dried for most commercial purposes, conditions that will prevent overdrying must be controlled and maintained. This means that the drying schedules ordinarily used for commercial kiln drying must be modified to suit boat material.

Drying schedules have been established for most commercial species, and the initial temperatures for green stock should be satisfactory for boat material. The relative humidity, however, should not be lowered below about 85 percent. Somewhat higher humidities may be required in some cases, particularly for oak more than 2 inches thick. Thus, through control of the relative humidity, the surface portions of the stock will not be dried below about 17 percent during the interval required to dry the core.

Most commercial kiln drying applies to 4/4-inch stock, some 8/4-, and a very limited amount of 12/4-inch and thicker. While it is comparatively easy to season 4/4-inch stock with very little degrade, difficulties mount rapidly as the thickness increases. Since boat lumber is not dried to so low a moisture content as commercial stock, less degrade should develop in a given thickness and, for the same reason, it should be possible to dry relatively thick material for boat lumber.

Surface checking is more common in boards 8 inches or more in width than in narrow stock, regardless of thickness. Hence, less surface checking would be expected in 4 by 6-inch decking than in 3 by 10-inch planking. Some species are more susceptible to drying defects than others, and such characteristics control the maximum thickness that can be dried. Generally, the softwoods are less difficulty to season than the hardwoods. The practical limits of thickness for stock dried to 20 percent moisture content are about 2 to 2-1/2 inches for oak and about 4 to 5 inches for softwoods.

Essentials of Good Kiln Drying

For the drying of stock from the green condition, the dry kiln must have both temperature and humidity automatically controlled so that optimum conditions of drying can be maintained. Circulation of air adequate both in uniformity and volume is necessary in order to control temperatures and humidity, hence fans, blowers, or other mechanical means of creating circulation are necessary.

The method of piling must be suited to the circulation system of the kiln. All lumber should be flat stacked, with edges of the load in vertical alignment.

Many lumber producers, particularly those cutting softwoods, have kilns of the type required and skillful operators. Such companies could undertake the drying of boat lumber for shipbuilders.

Water Storage

It is a practice of some boatbuilders to store under water pending their use in construction large timbers, natural crooks, knees, and the like. Since no drying takes place in the water, they do not check or split. As long as they are submerged they will not decay. Some builders are of the opinion that long exposure under water hastens the ultimate seasoning after removal from the water and minimizes shrinkage and checking. There may be some basis for this belief, though the advantages of water seasoning appear to be overemphasized. One definite advantage which develops when a piece is taken from the water and worked down for the part it is to serve before seasoning starts is that the reduced volume and size of the finished part compared to that of the original piece will reduce checking and splitting. This advantage is counterbalanced, however, by the fact that the seasoning takes place after shaping and while in position in the framework of the boat, and the shrinkage will thus cause some loosening of joints and fastenings. Occasionally, seasoning defects are serious enough to cause a timber or other member to be rejected, and it is better if the rejection is made before the piece is worked up than after it becomes a part of a boat frame.

Coatings

Moisture repellent coatings, such as oils, paints, or varnishes, are sometimes applied to wood surfaces after they are shaped in an attempt to retard surface drying. This method, though a worth while expedient, is only partially effective, and the parts are often subject to considerable checking and some shrinkage before the ship is launched. Moreover, some drying and checking may take place before the part reaches the stage where the coatings are applied. These coatings vary in degree of effectiveness from very low in the case of boiled linseed oil to fairly high in the case of two or more coats of lead and oil paint.

Chemical Soaking of Green Stock

Chemical treatments offer an effective means of retaining moisture in wood and thus reducing its tendency to shrink. That certain chemicals have hygroscopic properties, or the power to attract moisture from the atmosphere, is common knowledge. Table salt becomes wet and sticky in damp weather. Chemicals or salts in solution have the same property. Consequently, if a hygroscopic chemical is applied to green wood, it is dissolved in the contained water and the outer parts of the wood absorb some of the chemical. This impregnated zone partakes of the properties of the chemical solution, attracting moisture from the atmosphere when the relative humidity reaches a certain point. It will also maintain a higher moisture content than will natural wood under a definite atmospheric relative vapor pressure or humidity (Fig. 2). This phenomenon has been utilized by lumbermen in the salting of surface checked lumber to close the checks, and by shipbuilders in salting ships.

Whenever it is desirable to restrain the drying of ship members they may be treated with a chemical before installation. Such treatments do not assure that all checking and shrinkage can be eliminated, but they will materially reduce the extent of these defects. They are more effective when used on Douglas-fir than on oak but are worth while for oak. Further, chemically treated material will check less under proper kiln drying conditions than the same material would under normal air drying conditions. Common salt is cheap and effective, but corrosive. Urea, which is somewhat more costly, is both effective and noncorrosive.

The timbers may be soaked in an aqueous solution (35 parts by weight of common salt to 100 parts of water; or 100 parts of urea to 100 parts of water) for a week or more, or they may be sprinkled with the dry chemical. In the latter instance, green wood is piled with alternate layers of the chemical (the layer of chemical should be about 1/4 inch thick) and left undisturbed until the chemical has disappeared, but for not less than a week. The treatment should be applied as soon as possible after cutting the timbers. If this is done at the mill, the members will be protected during transit. If the surfaces of the lumber have become dry, they must be wet with water before the pile is constructed.

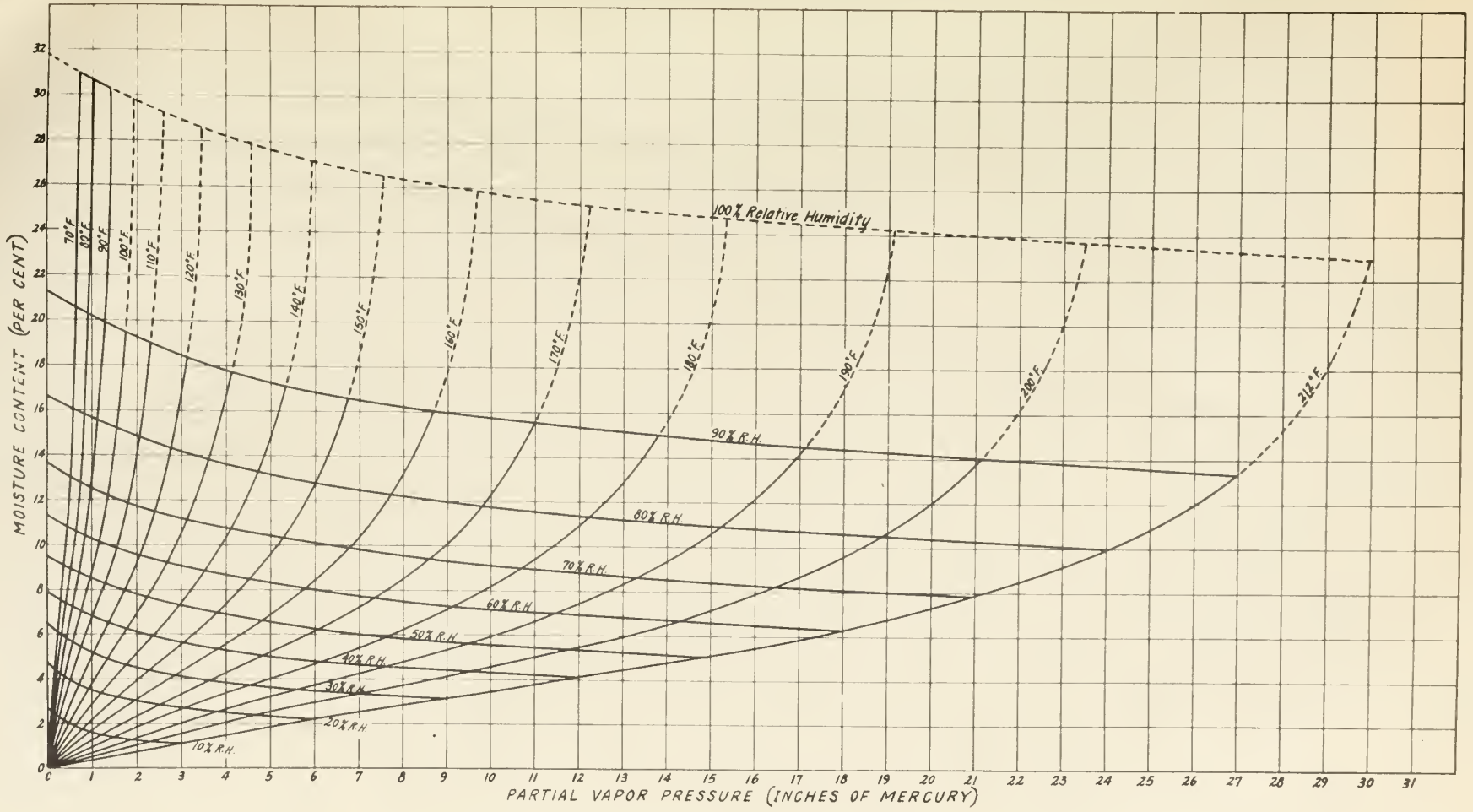
Where the dry method of application is used, the ends of planks and timbers should be sprayed or swabbed once daily for 5 days with a solution of the chemical, saturated at the temperature of application, to minimize end checking and splitting. Whether the treatment is applied by soaking or by the dry method, the chemical contained in the outer layers of the wood will reduce the amount of drying that takes place before launching and, thereby, decrease the amount of damage caused by drying.

The chemical will penetrate into the wood for about 1/4 inch, with the highest concentration at the surface. Any shaping or cutting that removes the impregnated wood exposes untreated wood, and normal moisture changes may be expected in that area. Stem pieces or similar parts that are worked deeply might be treated after working. Outside surfaces of planking should be painted as soon as possible after the smoothing operation. Other members that are worked or dressed deeply enough to cut off the treated zone should be painted or otherwise protected against moisture change.

The chemical treatment could be used to good advantage on all parts of the hull except the decking, which should be of seasoned material.

The use of unseasoned wood in ship construction increases the problem of painting and paint maintenance, particularly above the boot topping on exterior surfaces. The presence of the chemical adds to the problem to the extent that it increases the moisture content.

Insofar as is known, impregnating wood with these salts will not add to the hazard of stain and decay. In fact, the "salting" of wood ships as a protective measure against the growth of these organisms has been a recognized practice among shipbuilders for many years.



THE MOISTURE CONTENT OF SITKA SPRUCE
AT EQUILIBRIUM WITH THE INDICATED TEMPERATURE, PARTIAL VAPOR PRESSURE,
AND RELATIVE HUMIDITY

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Figure 1

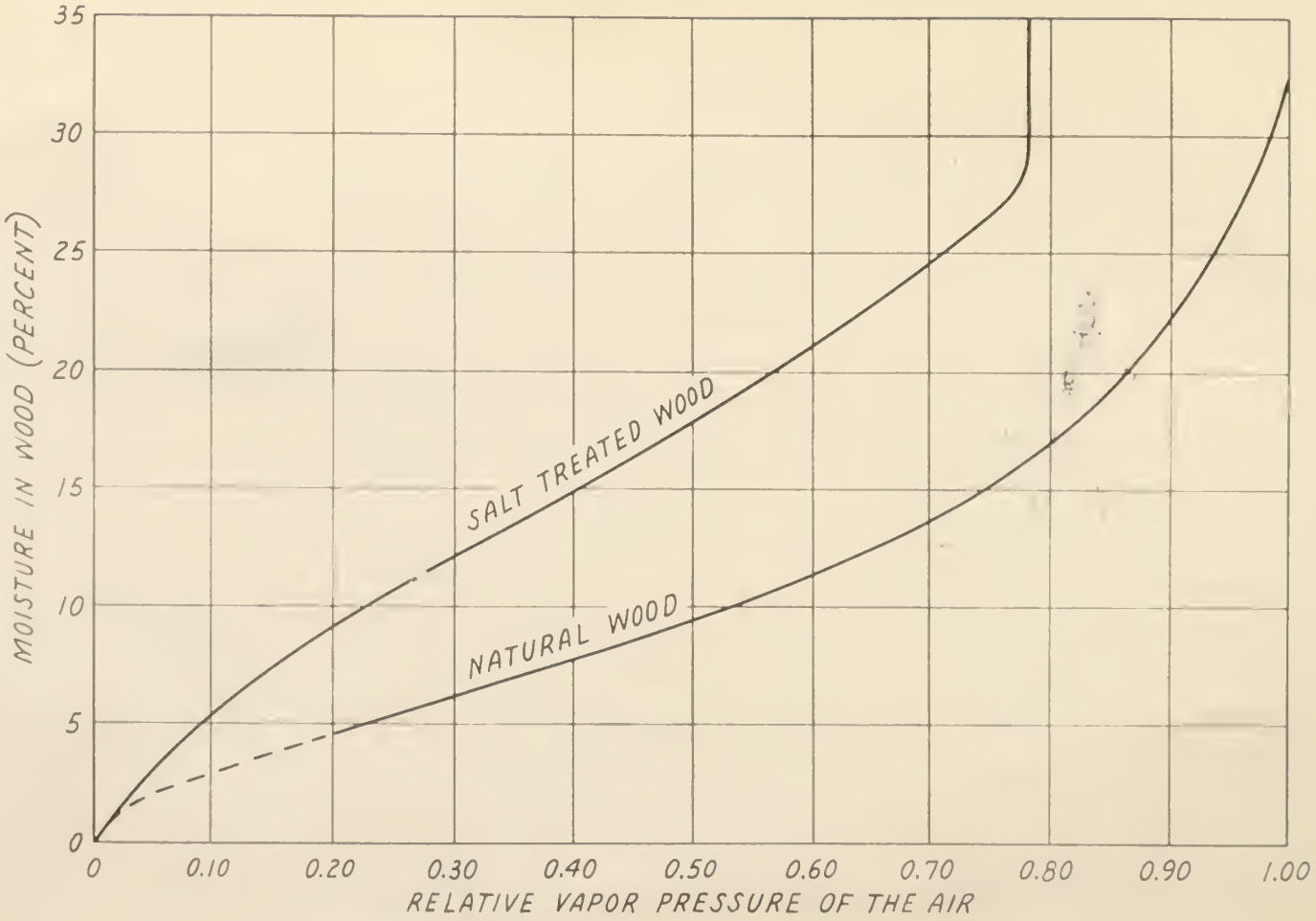

FIG. 2
EQUILIBRIUM MOISTURE CONTENT OF NATURAL WOOD
AND WOOD TREATED WITH A SATURATED SOLUTION OF SODIUM CHLORIDE.
BOTH CURVES FOR A TEMPERATURE OF 70°F.

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